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P01/7700 0.00-0317331.7

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1. Your Reference	P.7194 GBA
2. Patent application number *(The Patent Office will fill in this part)*	0317331.7 — 24 JUL 2003
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	NEW TRANSDUCERS LIMITED 37 Ixworth Place LONDON SW3 3QH G.B.
Patents ADP number *(if you know it)*	7283476003
If the applicant is a corporate body, give the country/state of its incorporation	G.B.
4. Title of the invention	ACOUSTIC DEVICE
5. Name of your agent *(if you have one)* "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	MAGUIRE BOSS 5 Crown Street St. Ives Cambridgeshire PE27 5EB G.B.
Patents ADP number *(if you know it)*	07188725001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country	Priority application number *(if you know it)*	Date of filing *(day/month/year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing *(day/month/year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if: a) any applicant named in part 3 is not an inventor, or b) there is an inventor who is not named as an applicant, or c) any named applicant is a corporate body:) See note (d)*	Yes

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Continuation sheets of this form	
Description	10 CF
Claims(s)	
Abstract	
Drawing(s)	4 only

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature Date: 24.07.2003

Maguire Boss

MAGUIRE BOSS

12. Name and daytime telephone number of person to contact in the United Kingdom JULIA GWILT Tel: 01480 301588

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Notes

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DUPLICATE

TITLE: ACOUSTIC DEVICE

DESCRIPTION

This invention relates to acoustic devices and more particularly to bending wave acoustic devices, e.g. loudspeakers.

Bending wave panel speakers, particularly Distributed Mode panel speakers, such as taught in WO 97/09842 and others to the present applicant, have the property of diffuse sound radiation resulting from complex bending wave action which beneficially provides wide directivity in all planes or directions. However in some applications a narrower directivity may be important, particularly in some axes or planes relative to others.

For public address purposes, for example for an airport concourse, the output of a loudspeaker is intended to be directed at the subjects. Maximum intelligible sound power is ideally directed over a specified range of height and over a wide horizontal area. If this narrower directivity requirement for the sound radiation in the vertical plane is not satisfactorily provided, sound power is wasted in driving the overall volume presented by the concourse and this wasted sound also degrades performance by echoing or reverberating around the space, degrading signal to noise ratio and reducing intelligibility.

Conventional piston/cone type line source speakers can achieve this to some degree, but suffer from significant interference between the arrays of piston elements at higher frequencies, which do not sum well in the acoustic space.

If the piston elements are then made smaller to address this issue, they have poorer low frequency output and power handling. If they are too large, the interference effects become dominant, spoiling the directivity performance. Compromises are therefore inevitable when using conventional piston drivers.

WO00/78090 to the present applicant describes a distributed mode bending wave panel speaker in which directivity in one plane is controlled by arranging the panel to have a modal axis and a non-modal axis orthogonal

to the modal axis. The panel can support a plurality of resonant bending wave modes in the predetermined frequency range along the modal axis. The fundamental frequency of resonant bending wave modes along the non-modal axis is at least five times the fundamental frequency of the resonant bending wave modes along the modal axis. In this way, the sound emitted from the panel is anisotropic at frequencies where resonant bending wave modes along the modal axis, but not the non-modal axis, are excited.

The panel may be narrow, and of high aspect ratio and designed to operate with the intended bending wave modes dominant in the direction of the longer axis. There may be a span of vibration exciters across the minor axis to further encourage the modal dominance in the major axis. Such modes radiate over a wide range of angles relative to the long axis and hence if the panel is horizontally mounted a wide directivity is achieved in the horizontal plane. This is an advantage if such a speaker is mounted in this attitude above or below a video screen, and good area coverage may thus be provided to the audience.

Such a speaker is also intended to have wide directivity with respect to the minor axis. This is achieved because the high aspect ratio component of the invention consequently prescribes a relatively short minor axis, which radiates with naturally wide directivity at frequencies where it is modal.

However there is also a different requirement for a bending wave speaker with improved directional sound radiation, one which has particularly narrow directivity in one axis and simultaneously wide directivity in the other axis. A good application is public address.

According to the present invention, there is provided a loudspeaker comprising a resonant panel of high aspect ratio, vibration exciting means coupled to the panel to excite the panel into resonance along the short axis of the panel, and means restraining or preventing resonance along the long axis of the panel whereby the panel radiates an acoustic output which is of wide directivity across the panel and of narrow directivity along the panel.

The vibration exciting means may also form the means restraining or preventing resonance along the panel. In this way, the length of the exciting means may be the key to controlling the directivity along the panel. The vibration exciting means is preferably longer than the wavelength of sound in air at the lowest required frequency. For example, for a public address speaker the line (and hence the length of the panel) should be at least 40cm long, giving a lowest nominal controlled directivity frequency of no more than 850Hz or so.

The vibration exciting means may comprise a line of discrete exciters extending along the panel and operated substantially in phase. The line may be rectilinear. The

line may extend substantially from one short end of the panel to the other short end.

There are preferably at least four exciters in the line. Three exciters are unlikely to be sufficient to control the directivity along the panel without excessive off-axis interference and consequent lobing in the corresponding polar response. The upper limit to the number of exciters is determined only by the size of the panel.

The line of exciters may be on the median longitudinal axis of the panel or to one side of the median axis, e.g. on the nodal line of the first lateral bending mode. The exciters may be equally spaced along the line. The spacing between exciters should be less than the wavelength of sound in the panel (not in the air) at the highest frequency of operation. Since the panel material is a determining factor in the highest frequency of operation, the spacing will therefore depend on the panel material selected.

The panel may be rectangular, with a main or major axis, and correspondingly a cross or minor axis. The panel may have an aspect ratio (i.e. ratio of length to width) of at least 2: 1. The panel length may be greater than the length of the exciter means. However, since the key to control directivity is the length of the exciter means, it is preferable for the exciter means to extend along the length of the panel.

The panel width may range from 8cm - 100cm, particularly for use in a public address system. If the width is below 8cm, the panel may not have sufficient low frequency bandwidth or output level to be effective. If the width is greater than 100 cm, the panel is likely to be impractical to handle and make.

The coincidence frequency of the panel is preferably approximately equal to or greater than the highest desired frequency. Otherwise, the vibration exciting means acting as the restraining means may produce strong off-axis lobing at the coincidence frequency which in turn may disrupt the reverberent sound-field in the acoustic space and reduce intelligibility.

In contrast to the teaching of WO00/78090, modes are encouraged for the minor cross axis to provide wide horizontal plane bending wave directivity when the rectangular panel is vertically orientated, as is common with public address speakers. Such an orientation also minimises mounting difficulties for architects and contractors. The speaker of the present invention may thus be considered to have the opposite acoustic effect of the speaker of WO00/78090. It is opposite both in principle and in action.

For the longer, major axis the bending wave panel provides a common surface for the extended source of excitation, which may be over a continuous line with a

suitable force exciter, or may result from a line represented by an array of discrete exciters, suitably connected electrically. Viewed in respect of the major axis the panel diaphragm approximates to an energy summation surface representing an extended, semi -coherent acoustic source and consequently has the required property of significantly narrowed directivity in the vertical plane due to the size of the source compared with the radiated wavelength.

The shaping of the directivity of sound radiation with frequency may be adjusted by the designer by determining the size of the major and minor axes, and if multiple exciters are used the level, frequency and phase response of the electrical signals connected to the exciters. Control of the exciters may be by conventional analogue or digital means. Other factors include the bending stiffness of the panel with respect to panel size and bending axis.

The technique of adjusting the drive line length with frequency, using electrical frequency sensitive networks, may be used to fine tune the vertical directivity over the frequency range. For example, the line may be significantly larger, e.g. more than 10 times longer, than the wavelength of the highest desired frequency. In this case, the directivity along the panel will be focused into a very narrow beam and spatial coverage will be limited. It may thus be desirable to employ filters to progressively

shorten the effective line length as the frequency increases.

The invention is diagrammatically illustrated in the following figures in which:

Figure 1 is a plan view of a speaker according to a first aspect of the invention;

Figure 2 is a plan view of a speaker according to a second aspect of the invention;

Figure 3 is a graph of the simulated acoustic output (dB) against frequency (Hz) for the speakers of Figures 1 and 2 mounted in an infinite baffle;

Figures 4a to 4c show the horizontal and vertical directivity of the speaker of Figure 2 at 3kHz, 1kHz and 250Hz respectively.

Figures 1 and 2 show a loudspeaker comprising a panel 10 to which an array of twenty-four exciters 12 are mounted to drive bending wave vibration in the panel. The panel is large having dimensions of 120cm by 40cm and thus has an aspect ratio of 3:1. Each exciter has a diameter of 25mm and the array of exciters extends from one short end to the other short end of the panel.

In Figure 1 the exciters 12 are equally spaced in a line running along the length of the long axis of the panel 10. In Figure 2 the exciters 12 are equally spaced on an off-axis line running along the length of the panel 10.

The off-axis line is the nodal line of the first lateral bending wave mode.

Figure 3 shows the simulated frequency responses 22, 24 for the loudspeakers of Figures 1 and 2 as solid and dashed lines respectively. The acoustic response of the loudspeaker of Figure 1 has a significant drop in sound pressure level at the first resonant bending wave mode of the panel, namely at 100 Hz. By mounting the exciters along the nodal line for this mode, as in the loudspeaker of Figure 2, this mode is excited and thus the frequency response is smoothed.

Figures 4a to 4c show the directivity 24, 26 in the planes passing through the short axis or long axis for the speaker of Figure 2 as dashed and solid lines respectively. The directivity in the planes passing through the short and long axis is the directivity across and along the panel respectively. If the speaker is vertically mounted, i.e. mounted with its long axis vertically, the directivity in the plane passing through only the short axis may be considered to be the horizontal directivity. Similarly, the directivity in the plane passing through only the long axis may be considered to be the vertical directivity. The directivity in the plane of the panel is not considered.

The horizontal directivity is substantially uniform at 3kHz and is perfectly uniform at 1kHz and 250Hz. In contrast, there is substantial beaming in the vertical

directivity at 3kHz and 1kHz with peaks when the measurements are taken on the short axis. The output drops away rapidly and significantly as the measurements are taken off-axis. The directivity is more uniform at 250Hz with the peaks on axis falling away more gently.

Thus the loudspeaker of Figure 2 may be used as a public address system for speech with a controlled directivity range of 250 - 3kHz. Above 3kHz the beaming is too strong to provide good coverage. The panel size is close to the largest which provides good coverage in a large public space without frequency shading.

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Fig. 1

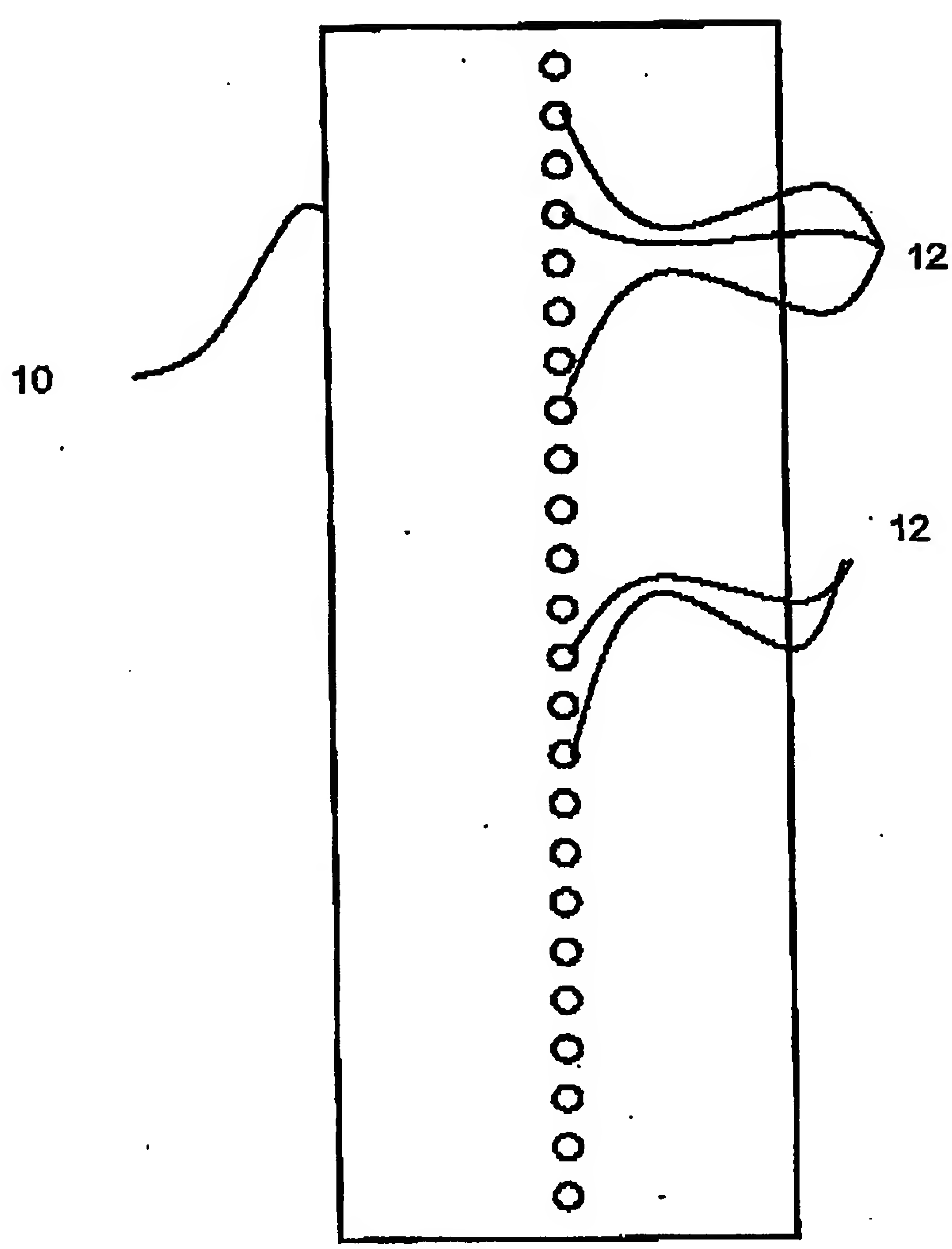

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Fig. 2

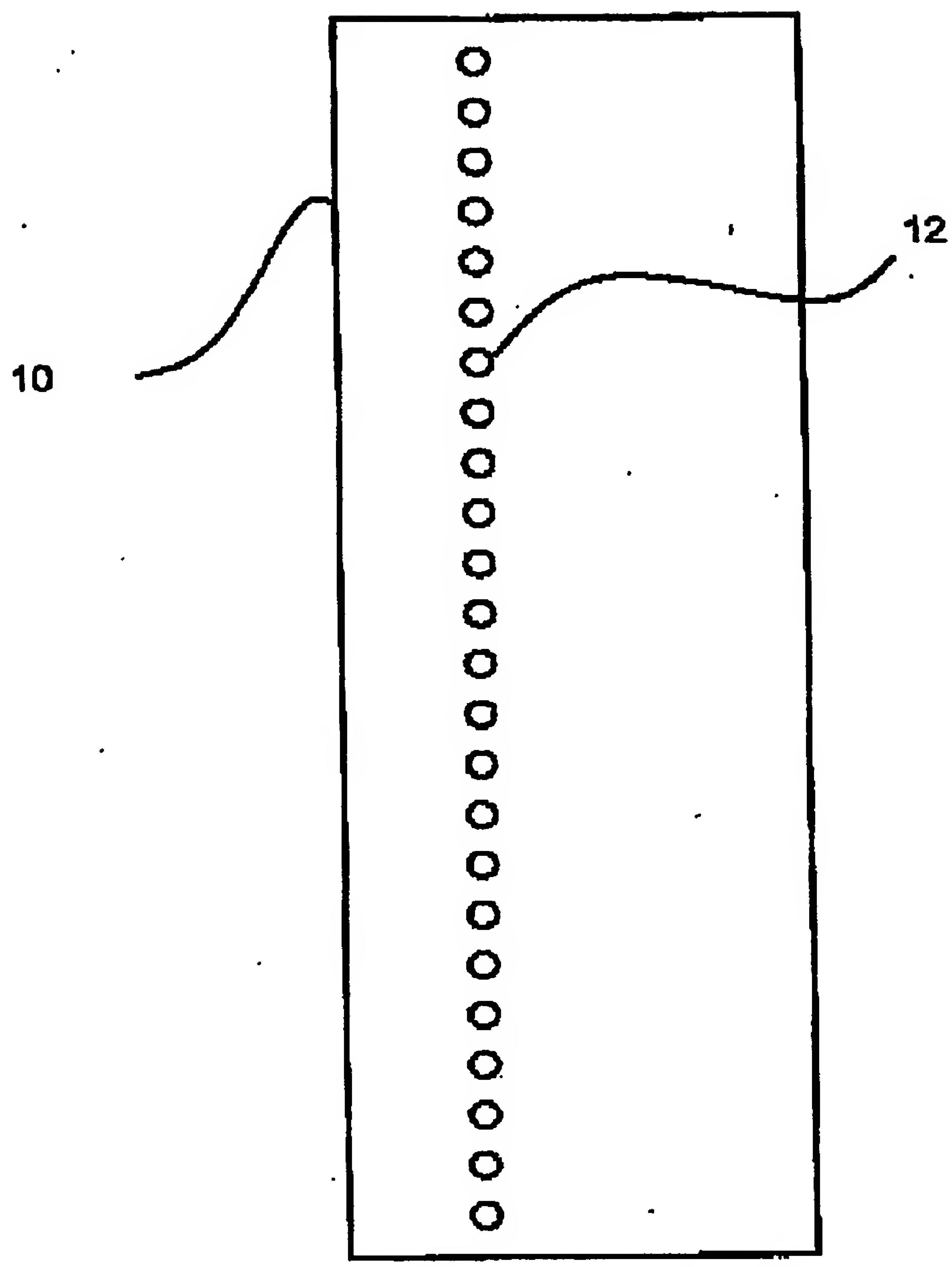

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Fig. 3

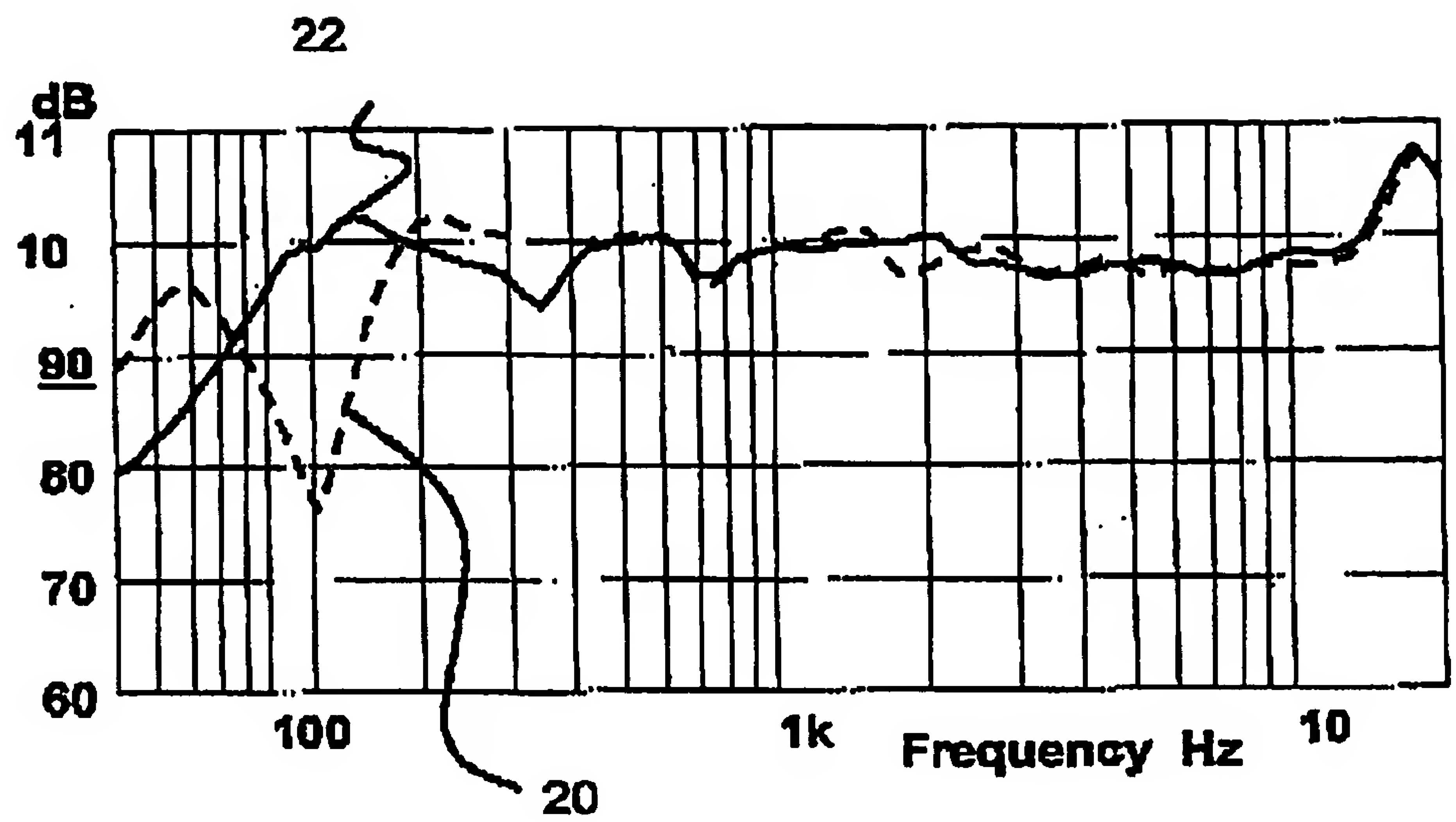


Fig. 4a

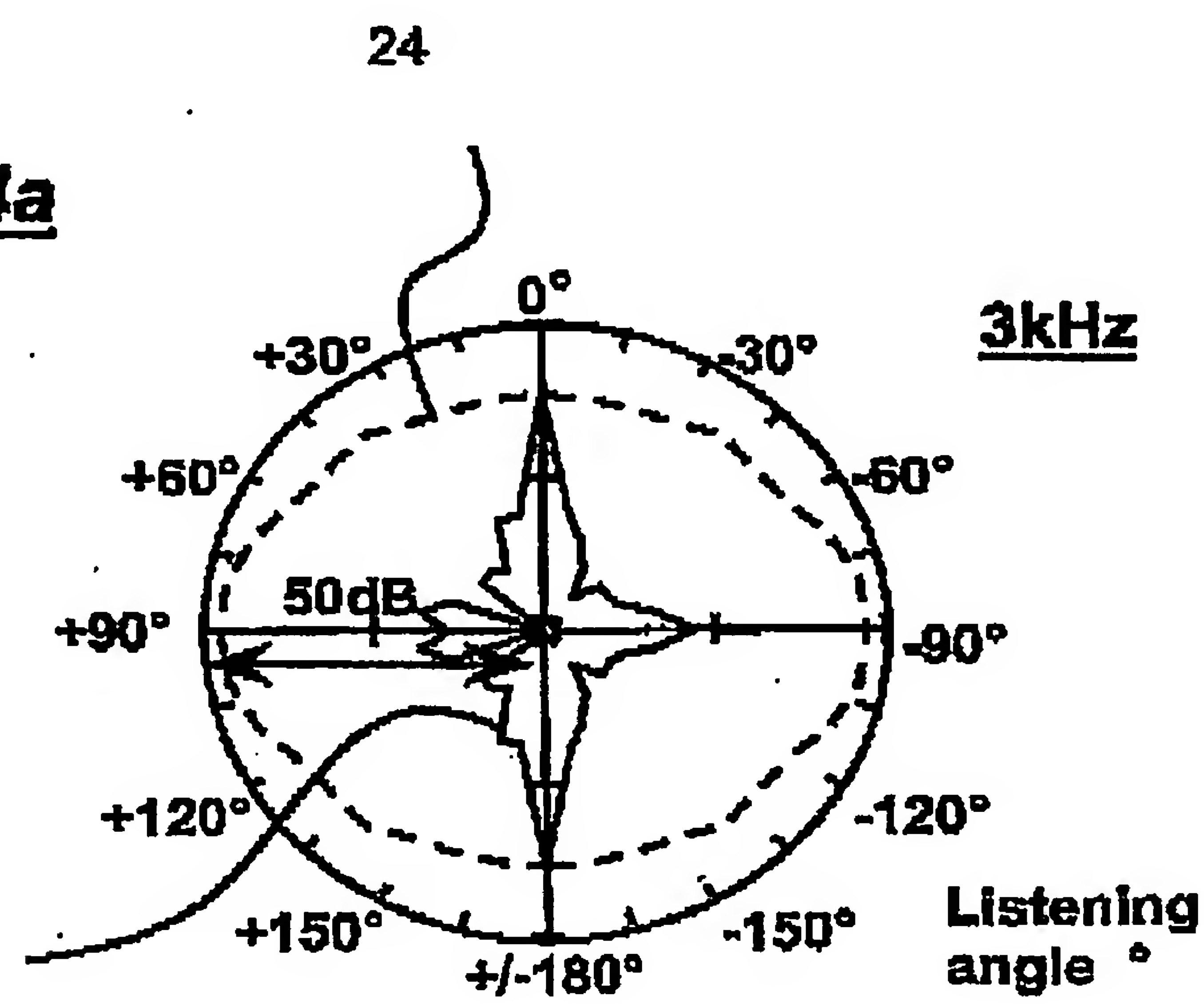


Fig. 4b

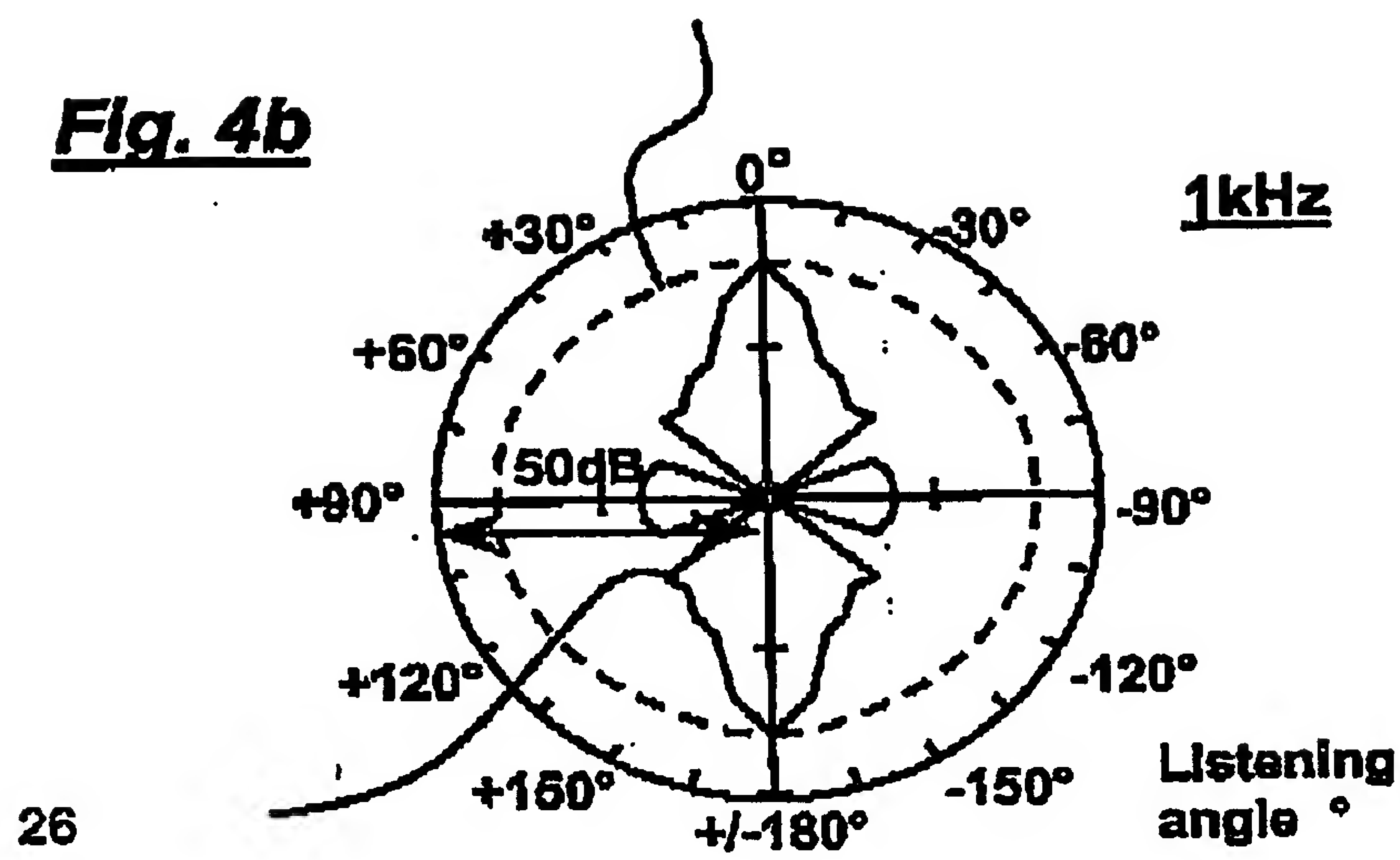
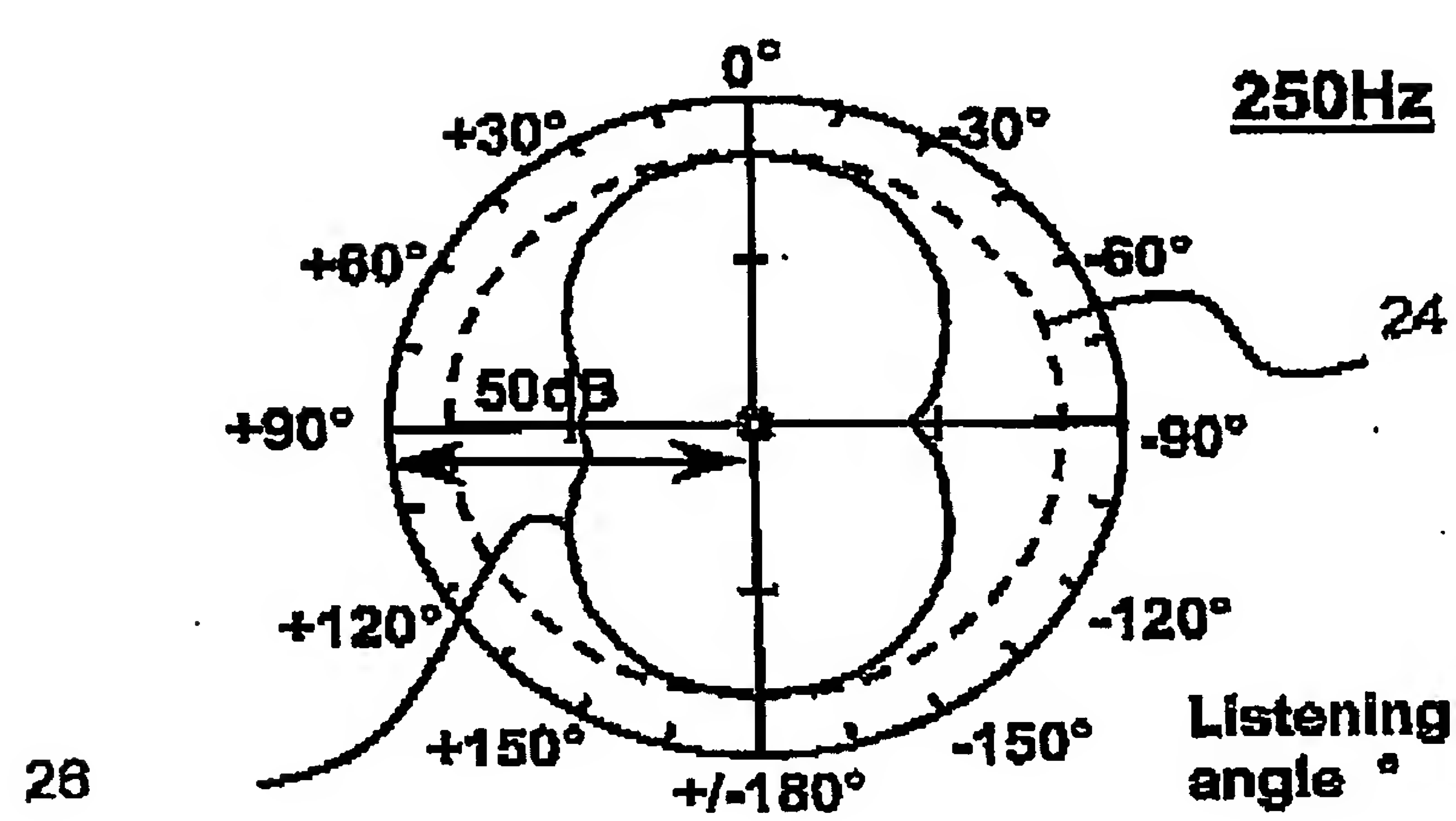

24
0°
+30°
-30°
1kHz
+60°
-60°
50dB
+90°
-90°
+120°
-120°
+150°
+/-180°
-150°
Listening angle °
26

Fig. 4c


0°
+30°
-30°
250Hz
+60°
-60°
24
50dB
+90°
-90°
+120°
-120°
+150°
+/-180°
-150°
Listening angle °
26